(12) UK Patent Application (19) GB (11) 2 069 286 A

(21) Application No 8041420
(22) Date of filing 29 Dec 1980
(30) Priority data
(31) 54/173825
(32) 27 Dec 1979
(33) Japan (JP)
(43) Application published
19 Aug 1981
(51) INT CL[3]
G01S 17/08
G03B 13/20
(52) Domestic classification
H4D 711 747 752 775 782
(56) Documents cited
GB 2012441A
GB 2010628A
GB 1334232
GB 1329864
GB 1310272
(58) Field of search
H4D
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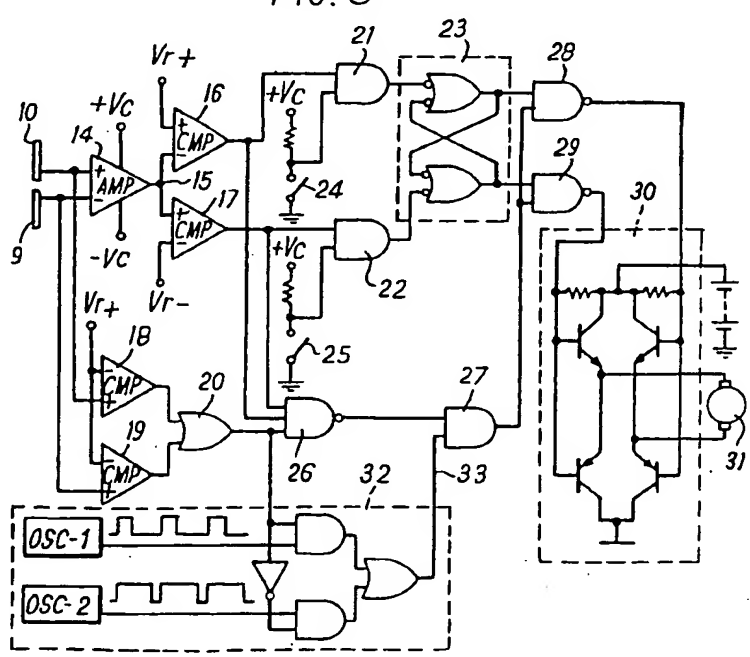
(54) Photographic camera of automatic focussing type

(57) A photographic camera of the automatic focussing type has light sensors (9, 10) which provide signals having an extreme value at the in-focus position. In a range near the in-focus position an electrical circuit (Figure 5) can detect the correct direction to move the objective towards the in-focus position. Outside this range the objective is moved in one direction, and if it reaches the limit of its travel without passing the in-focus position (i.e. it was driven the wrong way) one of two switches (24, 25) is actuated to reverse its direction. When outside the said range the objective is moved more quickly than when within it. Steps can be taken, especially if a self-scanning image sensor is used as light sensor, to compensate for changes in brightness avoiding changes in speed of movement of the objective on this account.

FIG. 5



The drawings originally filed were informal and the prints here reproduced are taken from later filed formal copies.

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FIG. 1

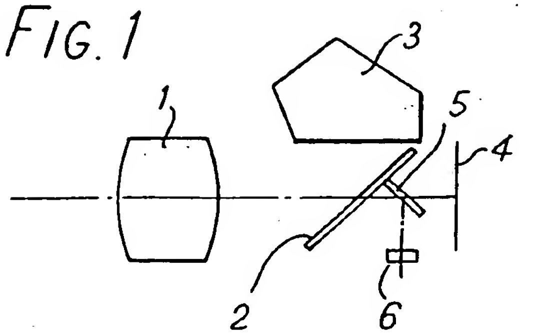


FIG. 2

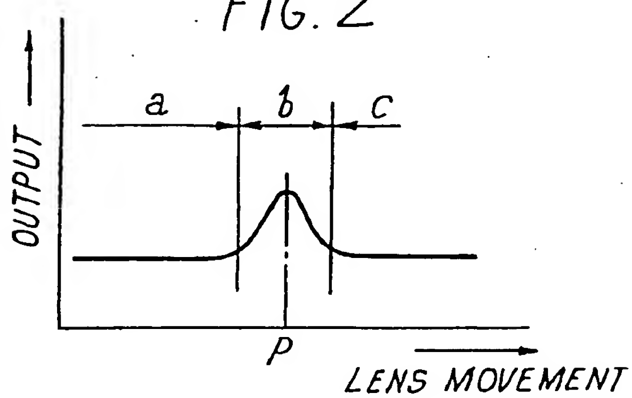


FIG. 3

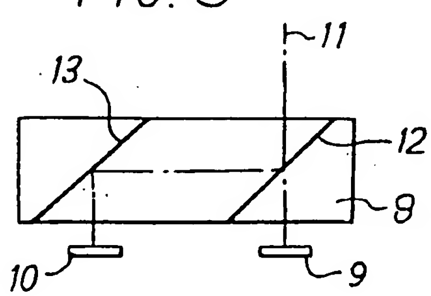


FIG.4

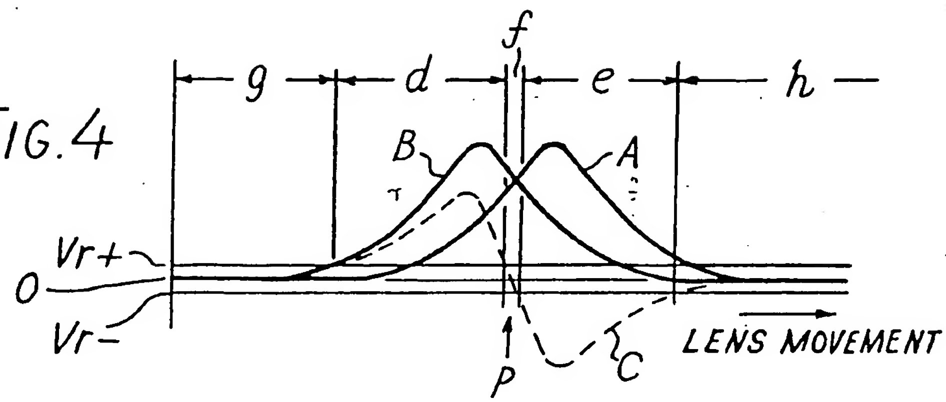

g
d
f
e
h
B
A
Vr+
O
Vr-
P
C
LENS MOVEMENT

FIG. 5

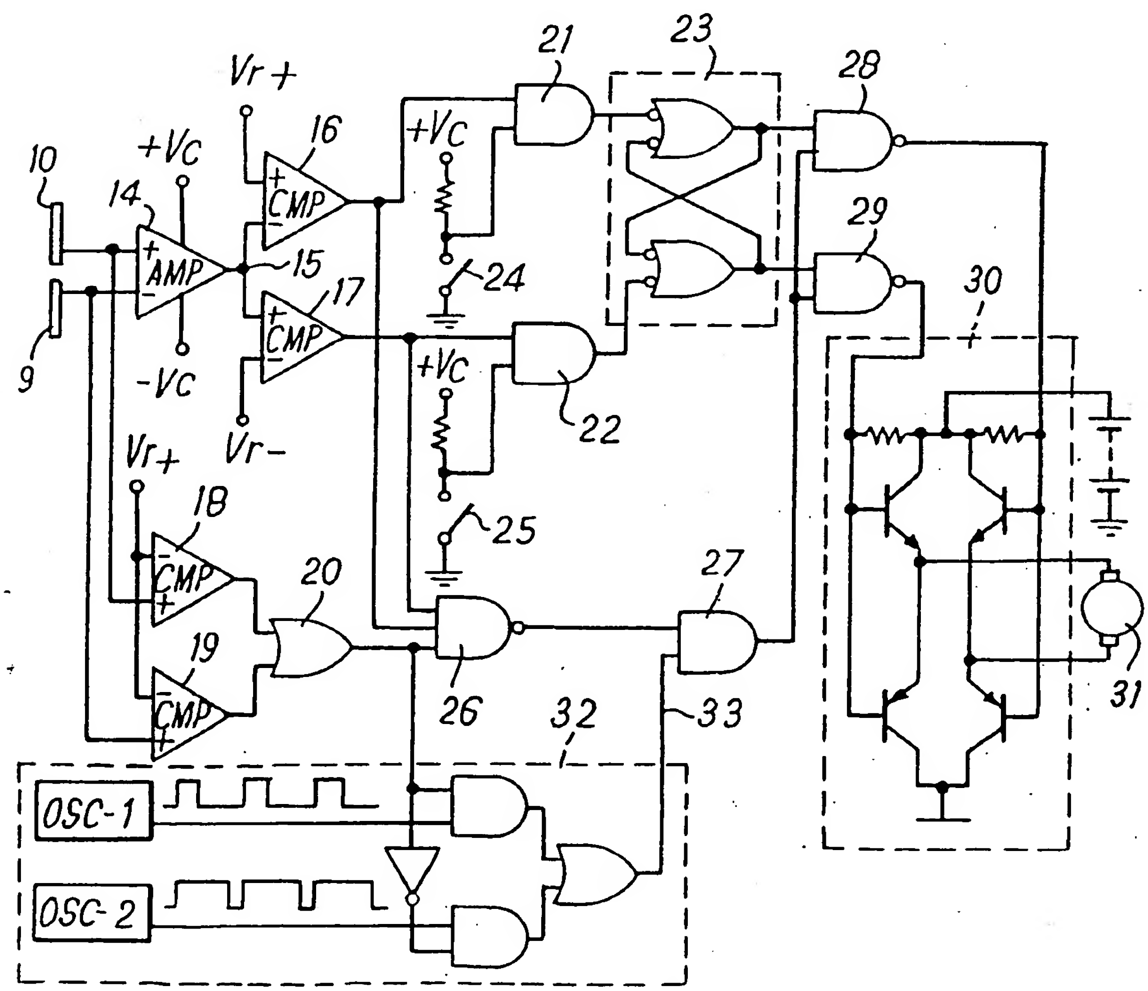

10
9
14
AMP
+Vc
-Vc
15
Vr+
Vr-
16
CMP
17
CMP
+Vc
24
25
21
22
23
28
29
30
31
18
CMP
19
CMP
20
26
27
33
32
OSC-1
OSC-2

FIG. 6

ZONE	g	d	f	e	h
16 OUTPUT	H	L	H	H	H
17 OUTPUT	H	H	H	L	H
20 OUTPUT	L	H	H	H	L

FIG. 7

DIRECTION OF MOVEMENT	INFINITY	STOP	MINIMUM DISTANCE
28 OUTPUT	L	H	H
29 OUTPUT	H	H	L

FIG. 8

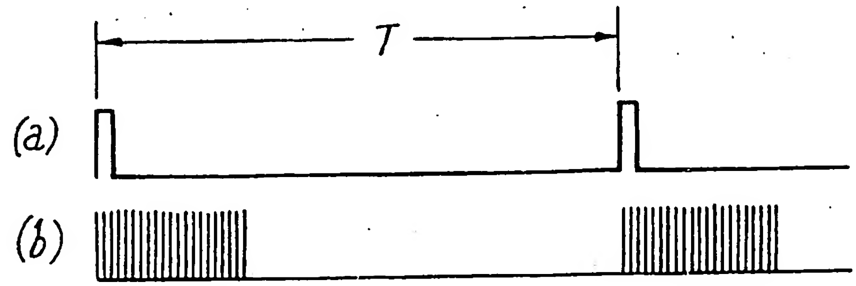


FIG. 9

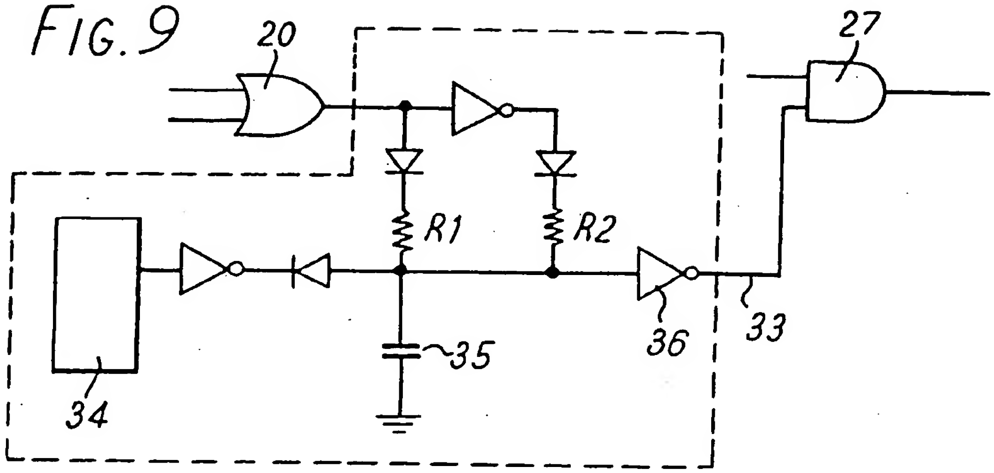
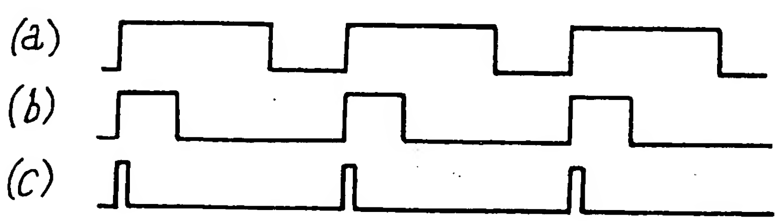


FIG. 10



SPECIFICATION

Photographic camera of automatic focussing type

There have already been proposed various focussing detectors using photoconductive elements, in which, for example, the non-linear characteristic of cadmium sulphide (CdS) exposed to light is utilized, or a plurality of small photoconductive elements are one- or two-dimensionally arranged, to extract a measure of the contrast of an image of an object to be photographed on the surfaces of these elements.

In using any of these previously-proposed photoelectric focussing detectors for a single-lens reflex camera, the photoelectric focussing detector has usually been located at a position optically equivalent to the film plane with respect to the reflective mirror disposed in the path of light coming through the objective from an object to be photographed. One example of such arrangement is illustrated by Figure 1 of the drawings.

Referring to Figure 1, reference numeral 1 designates the camera objective, reference numeral 2 designates a quick return mirror, reference numeral 3 designates a pentaprism, reference numeral 4 designates the film plane, reference numeral 5 designates a reflective mirror adapted to co-operate with said quick return mirror, and reference numeral 6 designates a photoelectric focussing detector.

In the example illustrated by Figure 1, the quick return mirror is partially formed as a half (semi-transmissive) mirror. With such arrangement of the photoelectric focussing detector, the detector is responsive only to ranging movement of the objective to generate a focussing signal, so that the mechanical structure is extremely simplified, but the following problem occurs. Namely, when the objective is in an out-of-focus position, the image of an object to be photographed is also out of focus on the focussing detector, and no signal indicating the focus condition is generated from the focussing detector.

Additionally, a slight movement of the objective from this state causes no variation in the output of the focussing detector. Accordingly, it is impossible to determine the direction in which the objective should be moved to obtain proper focussing.

Figure 2 illustrates this phenomenon by showing the variation occuring in the output from the photoconductive elements used for the focussing detector as a function of the amount of lens movement, in which P designates the in-focus position and *a, c* designate non-responsive zones. Symbol *b* designates a zone within which the signal indicating the focus condition is generated and which will be referred to as the responsive zone. It is possible within the responsive zone to move the objective to the focussing position based on a determination of the direction in which the output of the focussing detector varies as the objective is moved. However, it is impossible within the non-responsive zones to determine the direction in which the objective should be moved to bring the latter close to the in-focus position since no variation occurs in the output of the focussing detector. With a photographic camera of automatic focussing type utilizing the photoelectric focussing detector as mentioned just above, there occurs a probability of 1/2 that the objective will be moved in the direction opposite to the in-focus position when the objective is initially within one of the non-responsive zones.

The invention is defined in the appended claims to which reference should now be made.

In an exemplary camera system to be described, the objective if initially present within one of the non-responsive zones is moved at a high velocity to bring the objective away from this zone within as short a time as possible and, even if it happens that the objective has been moved in the direction opposite to the in-focus position, switch means reverses the focussing drive motor upon arrival of the objective at the position for photographing an object at the infinite distance or at the minimum distance to reverse movement of the objective in the proper direction. When the objective having been moved at high velocity enters into the responsive zone, the feed velocity of the objective is effectively reduced to improve the focussing precision and to prevent the objective from being fed far beyond the in-focus position due to its inertia. Thus, hunting or oscillation of the objective relative to the focussing position is prevented and the objective directly stops at the in-focus position.

The invention will now be described in more detail, by way of example, with reference to the drawings, in which:

Figure 1 illustrates by way of example an arrangement of a photoelectric focussing detector;

Figure 2 is a diagram illustrating how the output from the photoconductive element used in the photoelectric focussing detector varies as the objective is driven;

Figure 3 schematically illustrates a photoelectric focussing detector using therein two photoconductive elements.

Figure 4 is a diagram illustrating how the output from the photoelectric focusing detector varies as the objective is driven;

Figure 5 is a circuit diagram illustrating a preferred circuit arrangement incorporated into a photographic camera of automatic focussing type;

Figure 6 is a table showing the relationship between the outputs at points of the circuit illustrated by Figure 5 in each zone illustrated by Figure 4;

Figure 7 is a table showing a relationship between the output from each gate 28, 29 illustrated by Figure 5, and the direction of movement and stopping of the objective;

Figure 8 illustrates the output waveform (a) and the scanning pulse train (b) of the scan initiating signal oscillator for an image sensor of self scanning type;

Figure 9 is a circuit diagram illustrating a circuit arrangement adapted to provide a rectangular waveform output at different duty ratios for the responsive zones and for the non-responsive zones in synchronization with the scan initiating signal for the image sensor of self scanning type and thereby to regulate the speed of the focussing motor depend-

ing upon the luminance of an object to be photographed; and

Figure 10 illustrates output of the circuit illustrated by Figure 9.

Figure 1 illustrates by way of example arrangement of photoelectric detector 6 for focussing of such type as has already been mentioned and Figure 2 illustrates how output of a photoconductive element incorporated in said photoelectric focussing detector varies as the objective moves in the manner as also has previous been described. A photoelectric focussing detector which is suitable for use in the single lens reflex camera is described in detail in our Japanese Patent Application No. 15255 filed in 1979 (U.K. Patent Application No.) and, therefore, description of the present device will be made with respect to such a photoelectric focussing detector. The photoelectric focussing detector described in Japanese Patent Application No. 15255 of 1979 comprises a pair of photoconductive elements adapted to provide an output signal as illustrated in Figure 2 utilizing co-operating means such as an image sensor of the self-scanning type and a light splitter by which said pair of photoconductive elements are combined with each other so as to be spaced a small distance from each other across a plane optically equivalent to the film plane. Such an assembly is arranged at the position of the photoelectric focussing detector 6 in Figure 1. By thus arranging a pair of photoconductive elements slighly spaced from each other, it is possible to determine the direction in which the objective has to move to achieve focussing as will be described later.

Figure 3 illustrates the photoelectric focussing detector disclosed in Japanese patent application No. 15255 of 1979, in which a reference numeral 8 designates a light splitter, reference numerals 9, 10 designate photoconductive elements adapted to provide the output signal as illustrated in Figure 2 in co-operation with an image sensor of self-scanning type or the like, reference numeral 11 designates the optical axis, reference numeral 12 designates a semi-transparent mirror and reference numeral 13 designates a total reflection surface. In the following description, the photoconductive element 9 will be referred to as the front element and the photoconductive element 10 will be referred to as the rear element.

Figure 4 illustrates the variation of the output waveform provided from the photoelectric focussing detector of Figure 3 as the objective is moved. A waveform A corresponds to the output of the front element 9, a waveform B corresponds to the output of the rear element 10, and a waveform C corresponds to said output of the rear element 10 minus said output of the front element 9. The position occupied by a point P is in the in-focus point. In Figure 4, properly set threshold values Vr^- and Vr^- intersect the waveform C and thereby define zones *d, e, f, g* and *h*. Of these the zones *d, e* and *f* are said responsive zones within which it is possible to determine the proper direction in which the objective is to be moved, in accordance with the polarity of the waveform C, in order to achieve focus. The zone is here referred to as the focussing zone within which the desired focussing is achieved by the objective being present therein. The other zones *g* and *h* are said non-responsive zones. If the objective is within one of these two zones, it is impossible to determine the proper direction in which the objective is to move for focussing. To realize a photographic camera of automatic focussing type which can be operated at high stability, precision and speed, it is very important that said threshold values Vr^+ and Vr^- should be carefully determined to the proper values, since these values largely contribute to the stabilization not only of the width of the focussing zone *f* but also of the control operation.

Figure 5 is a circuit diagram illustrating an embodiment of the present invention using the photoelectric focussing detector as illustrated in Figure 3. In Figure 5, reference numerals 9, 10 designate said photoconductive elements constituting the photoelectric focussing detector, providing the outputs A and B as shown in Figure 4, respectively. The outputs from the photoconductive elements 9, 10 are applied to a differential amplifier 14 which, in turn, provides at its output terminal 15 an output designated by C in Figure 4. This output is compared by comparators 16, 17 with the threshold values Vr^+ and Vr^-, respectively. The outputs of the photoconductive elements 9, 10 are also compared by comparators 18, 19 with the threshold value Vr^+ and an output of a gate 20 becomes H (high) when any one of said two output is higher than Vr^+. Thus, the output of the gate 20 is "H" within the responsive zones *d, e, f* and is "L" (low) within the non-responsive zones *g, h* of Figure 4. A relationship between the outputs of the comparators 16, 17 and the gate 20, and the respective zones *d* to *h* of Figure 4 is tabulated in Figure 6. It will be seen from Figure 6 that the output "L" of the comparator 16 instructs feeding of the objective towards the position for photographing an object at the minimum distance while the output "L" of the comparator 17 instructs feeding of the objective towards the position for photographing an object at the infinite distance, since in the zone *d* in Figure 4 proper focussing can be obtained by moving the objective lens towards the minimum distance position and in the zone *e* towards the infinity position.

The outputs of the comparators 16, 17 are applied via gates 21, 22 to a flip-flop 23. Switches 24, 25 are adapted to be closed upon arrival of the objective at the positions for photographing the objects at the infinite distance and at the minimum distance, respectively, and these switches are normally open, so that the gates 21, 22 allow the outputs of the comparators 16, 17 to be directly applied to the flip-flop 23. Within the focussing zone *f*, the comparators 16, 17 and the gate 20 have the output "H" as seen from Figure 6, such output is detected by a gate 26 and then a detection signal serving to stop the focussing motor is applied together with the output signal from the flip-flop 23 via a gate 26 to gates 28, 29. Accordingly, a relationship is given between the outputs of the gates 28, 29 and the rotation direction or stopping of the focussing motor, as tabulated in Figure 7.

An electric circuit 30 encircled by a broken line in

Figure 5 is a power amplifier serving to rotate the focussing motor 31 in accordance with the outputs of the gates 28, 29. An electric circuit 32 encircled by a broken line is a control circuit adapted to drive the objective at a higher velocity within the non-responsive zones while at a lower velocity within the responsive zones. OSC-1, OSC-2 designate oscillators adapted to provide rectangular wave outputs at the same frequency having different duty ratios so that the output of the OSC-1 is applied to an input terminal 33 of the gate 27 when the gate 20 provides the output "H" and the output of the OSC-2 is applied to the input terminal 33 of the gate 27 when the gate 20 provides the output "L". Even when the gate 26 provides the output "H" or the desired focussing is still not achieved, the focussing motor 31 is momentarily stopped at the "L" portion of the output waveform of the OSC-1 or the OSC-2. Accordingly, the duty ratio of the OSC-1 may be set lower than the duty ratio of the OSC-2 in order that the focussing motor 31 is rotated at a higher average speed when the objective is present within one of the non-responsive zones or the gate 20 provides the output "L", and the focussing motor 31 is rotated at a lower average speed when the objective is present within one of the responsive zones or the gate 20 provides the output "H", with a result that the objective is driven at the corresponding velocity. During movement of the objective at such high velocity within the non-responsive zones, the objective may sometimes move away from the in-focus point, since it is impossible, as previously mentioned, to determine the proper direction in which the objective is to move when the objective is initially present within one of the non-responsive zones. In such case, the switch 24 is closed upon arrival of the objective at the position for photographing an object at the infinite distance ad the switch 25 is closed upon arrival of the objective at the position for photographing an object at the minimum distance so that the input terminals of the respective gates 21, 22 are converted into the state "L", resulting in that the flip-flop 23 has its state inverted and thereby rotation of the focussing motor is reversed so as to drive the objective in the proper direction for focussing.

With the aforementioned arrangement, the objective is fed at a higher velocity when the objective is initially remote from the focussing point and at a lower velocity when initially near the focussing point, so that the automatic focussing function can be achieved at high rapidity, precision and stability even in a photographic camera of automatic focussing type which is of a relatively simple construction. Especially when an image of an object to be photographed or the objective is present within one of the responsive zones, even a mobile object can be followed without any disturbance of focussing. Even an object to be photographed which has its image initially within one of the non-responsive zones can be rapidly brought into the responsive zone.

The photoelectric focussing detector relies upon light rays coming from an object to be photographed through the objective, and is therefore compatible with an interchangeable lens system. This means that such detector is suitable for the single lens reflux camera. The element serving to be exposed to said light rays in the photoelectric focussing director may be a CdS element or an image sensor of self-scanning type, so long as such element provides an output as illustrated in Figure 2 with a suitable signal processing. Recently, relating to the photoelectric focussing detector using therein said image sensor of self scanning type, many patent applications have been filed, among which the Japanese patent application No 15254 of 1979 (UK Patent Application No.) has proposed how to enlarge the dynamic range of the image sensor of self scanning type with respect to a quantity of light. According to this patent application, the brightness of an object to be photographed is detected by a separate element and a level of thus detected luminance determines a level of the signal serving to initiate the scanning operation of the image sensor of self scanning type. This feature is claimed to enable focussing to be obtained over a wide range from a relatively dark object to be photographed to a relatively bright object to be photographed, since the outputs from the detector as illustrated in Figure 2 take the same waveform even with respect to different average luminances, so long as an object of the same contrast is concerned.

In accordance with this prior patent application, the signal serving to initiate scanning of the image sensor of self scanning type is generated by the oscillator as illustrated by Figure 9 of the accompanying drawing. This will be refered to, hereinafter, as the scanning function initiating signal oscillator. The output of this oscillator is illustrated by Figure 8(a) and a series of scanning pulses of the image sensor of self scanning type which are generated from a separate oscillator energized by the output (a) is illustrated by Figure 8(b). For an object of a higher luminance, the scan initiating signal has a higher frequency, resulting in a shorter period T in Figure 8 while for an object of a lower luminance, the scan initiating signal has a lower frequency, resulting in a longer period T in Figure 8, so that the quantity of accumulated electric charges in the image sensor can be kept constant and the output as illustrated by Figure 2 can be constant independently of the luminance of the object to be photographed. However, the fact that the object of lower luminance results in correspondingly lower frequency of the scan initiating signal means that the focussing detector can not respond as rapidly to such object of lower luminance. In consequence, the camera of automatic focussing type incorporated with such photoelectric focussing detector would exhibit the disadvantage that, for an object of lower luminance, the velocity at which the objective can be driven is too high relative to the response of the focussing detector. Namely, a stopping signal may occur after the objective has been driven far beyond the in-focus point and then a direction inverting signal may occur, resulting in so-called hunting relative to said in-focuss point. In an extreme case, the objective may be fed from one of the non-responsive zones directly to the non-responsive zone of the opposite side before the focussing detector generates a signal indicating that

the objective has entered into the corresponding responsive zone, with the result of a reciprocal movement of the objective between the positions for photographing an object at the infinite distance and an object at the minimum distance. To avoid such disadvantageous phenomenon, it is desirble to feed the objective at a velocity depending upon the luminance of the object to be photographed so that the objective can be effectively operated for wide range of requirement, i.e., not only for the object of higher luminance but also for the object of lower luminance.

Such requirement for operation is satisfied by a circuit arrangement illustrated by Figure 9, in which an electric circuit encircled by a broken line replaces the circuit section 32 in Figure 5. A reference numeral 34 designates said scan initiating signal oscillator having its output waveform as illustrated by Figure 8(a). A reference numeral 35 designates a capacitor adapted to be discharged in response to a clock pulse from the scan initiating signal oscillator. Said capacitor 35 is charged through a resistance R1 when the objective is present in one of the responsive zones, since the output from the gate 20 is then at the "H" state while through a resistance R2 when the objective is present in any one of the non-responsive zones, since said output is then at the "L" state. During a period in which the capacitor 35 has its charging voltage lower than the threshold value of an inverter 36, the latter has its output at the "H" state. Accordingly, the value of the resistance R2 may be set to a level higher than the value of the resistance R1 so that the inverter 36 provides an output waveform of a longer period of "H" when the objective is present within one of the non-responsive zones and provides an output waveform of a shorter period of "H" when the objective is present within one of the responsive zones, as seen from Figure 10(a) and (b) respectively in synchronization with the scan initiating signal as illustrated by Figure 10(c). The output from the inverter 36 is applied to the input terminal of the gate 27 so as to rotate the focussing motor during the period of "H", so that the objective which is initially present within one of the non-responsive zones is driven at a higher velocity than when the objective is initially present within one of the responsive zones. Furthermore, the objective is driven at a higher velocity for an object of higher luminance than for an object of lower luminance, because the period during which the output from the inverter 36 is at the "H" state is synchronized with the scan initiating signal pulse and the frequency of this scan initiating signal pulse depends upon the luminance of the object to be photographed as previously mentioned.

With the circuit arrangement and the operation thereof as have been mentioned hereinabove, the velocity at which the objective is driven depends upon the luminance of the object to be photographed so that, even though the focussing detector can not be rapidly responsive to an object of lower luminance, the objective can be fed at a correspondingly lower velocity to obtain a reliable focussing signal. It is thus possible to obtain the photographic camera of automatic focussing type which is useful over a wide range of object conditions.

CLAIMS

1. A photographic camera of the automatic focussing type, comprising a photosensitive focussing detector, and means operable when the output of the detector fails to indicate positively the direction of the in-focus position and effective to move the objective in one direction and, if it reaches the end of its travel to reverse the direction of movement.

2. A camera according to claim 1, in which the said means moves the objective at a higher speed when the detector fails to provide a positive indication of the direction of the in-focus position than when it does.

3. A photographic camera of the automatic focussing type comprising a photoelectric focussing detector utilizing a photoconductive element adapted to be responsive to light coming through an objective from an object to be photographed to generate an electric signal having an extreme value when an image of the object formed on the photoconductive element is in the optimal focussed condition; en electric circuit adapted to determine the proper drive direction of the objective based on the variation of the output signal from said photoelectric focussing detector as the objective is displaced and thereby to generate an electric signal indicating the proper direction of rotation and stopping of a focussing motor for driving the objective; an electric circuit adapted to generate an electric signal with which the focussing motor is rotated at a high speed so as to drive the objective at a high velocity when the objective is initially present within a zone which is so far from the in-focus position that no variation occurs in the output from said photoelectric focussing detector as the objective is moved and thus it is impossible to detect the focussing condition and to generate an electric signal with which the focussing motor is rotated at a low speed so as to drive the objective at a low velocity when the objective is initially present sufficiently close to the in-focus position that it is possible to detect the focussing condition based on a variation occurring in the output from said photoelectric focussing detector as the objective is moved; and a first switch adapted to be actuated when the objective has arrived at the infinite focus position and a second switch adapted to be actuated when the objective has arrived at the minimum focus position wherein the first switch or the second switch, when actuated, functions to reverse the rotation of the focussing motor.

4. A photographic camera of the automatic focusing type comprising a photoelectric focussing detector consisting of an image sensor of the self-scanning type utilizing a photoconductive element adapted to be responsive to light coming through an objective from an object to be photographed to generate an electric signal having an extreme value when an image of the object formed on the sensor is in the optimal focussed condition; an electric circuit adapted to determine the proper

drive direction of the objective based on the variation of the output signal from said photoelectric focussing detector as the objective is displaced and thereby to generate an electric signal indicating the proper direction of rotation and stopping of a focussing motor for driving the objective; an electric circuit adapted to generate an electric signal with which the focussing motor is rotated at a high speed so as to drive the objective at a high velocity when the objective is initially present within a zone which is so far from the in-focus position that no variation occurs in the output from said photoelectric focussing detector as the objective is moved and thus it is impossible to detect the focussing condition and to generate an electric signal with which the focussing motor is rotated at a low speed so as to drive the objective at a low velocity when the objective is initially present sufficiently close to the in-focus position that it is possible to detect the focussing condition based on a variation occurring in the output from said photoelectric focussing detector as the objective is moved; an electric circuit adapted to regulate the frequency of a scan initiating signal for the image sensor depending upon the luminance of an object to be photographed and to generate rectangular waveform output signals in synchronization with said frequency of the scan initiating signal at different duty ratios between when the objective is initially present within said focussing detectable zone and when the objective is initially present within said focussing undetectable zones; and a first switch adapted to be actuated when the objective has arrived at the infinite focus position and a second switch adapted to be actuated when the objective has arrived at the minimum focus position; wherein the first switch or the second switch, when actuated, functions to reverse the rotation of the focussing motor, and the velocity at which the objective is driven by the rotation of the focussing motor is under the control of said rectangular waveform output signals of different duty ratios.

5. A photographic camera of the automatic focussing type, substantially as herein described with reference to the drawings.

Printed for Her Majesty's Stationery Office by Croydon Printing Company Limited, Croydon, Surrey, 1981.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.